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BIOLOGICAL OBSERVATIONS ON *HEMISARCOPTES COCCOPHAGUS* MEYER (ACARI: ASTIGMATA: HEMISARCOPTIDAE) ASSOCIATED WITH WILLOW ARMORED SCALE, *CHIONASPIS SALICIS* (L.) (HEMIPTERA: DIASPIDIDAE) IN ERZURUM, TURKEY

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Abstract.—The willow armored scale insect, *Chionaspis salicis* (L.) (Homoptera: Diaspididae) is an important pest of willow (*Salix* spp.), poplar (*Populus* spp.), and elm (*Ulmus* spp.) trees, particularly in the eastern part of Turkey. *Hemisarcoptes coccophagus* Meyer (Acari: Astigmata: Hemisarcoptidae) was observed attacking egg and nymph stages of *C. salicis*. This predatory mite species overwinters in adult and nymphal stages, rarely eggs, under the shield of *C. salicis* in the field. It has three generations in the vicinity of Erzurum. From the beginning of April to the end of October, *H. coccophagus* was active, consuming an average of 35% (up to 49%) of the eggs of *C. salicis* and could be considered a candidate for the biological control of *C. salicis*.

Key Words: Willow armored scale insect, *Chionaspis salicis*, *Hemisarcoptes coccophagus*, predatory mite, biocontrol agent, Turkey

The willow armored scale insect, *Chionaspis salicis* (L.) (Homoptera: Diaspididae), is considered one of the severe pests on willow (*Salix* spp.), poplar (*Populus* spp.), and elm (*Ulmus* spp.) trees in Turkey and is widely distributed in the country (Bodenheimer 1949, 1952, 1953; Aysu 1950; Tuatay et al. 1967, 1972; Yıldız 1972; Çanakçıoğlu 1977; Yaşar 1995; Çalmaşur et al. 2000). It is often very injurious particularly to smaller trees. On heavily infested trees, the entire surface of the bark may be coated with the overlapping dirty-white scales and show signs of reduced vigor; the foliage becomes more or less yellow and spotted; and the twigs, shoots and occasionally the entire trees die (Çalmaşur et al. 2000). Recently, *C. salicis* reached very high populations on some willow trees in various localities of Erzurum, Turkey.

Mites of the genus *Hemisarcoptes* (Acari: Astigmata: Hemisarcoptidae) are small (≈300 μm) and soft bodied, and are widely distributed. The mobile stages (larva, protonymph, and adult) are specialized predators of armored scale insects (Gerson and Schneider 1981; Gerson et al. 1990; Houck and OConnor 1990; Hill et al. 1993; Izraylevich and Gerson 1993, 1995a). *Hemisarcoptes coccophagus* Meyer is an Old World species, so far recorded from Spain, the Middle East, and northern African countries, and appears to survive under extreme climatic conditions (Gerson et al. 1990).

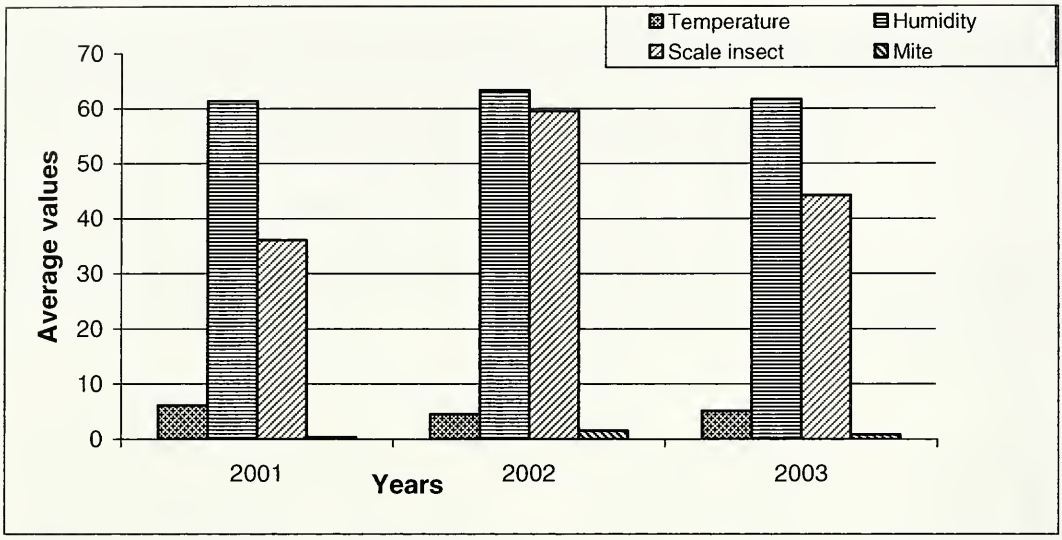


Fig. 1. Annual averages of temperature, humidity, *Chionaspis salicis*, and *Hemisarcoptes coccophagus* (2001, 2002, and 2003) in Erzurum, Turkey.

Several studies have been conducted on the biology, population structure, phoresy, sex ratio, host preferences, and population dynamics of *Hemisarcoptes coccophagus* in Israel (Izraylevich and Gerson 1993, 1995b, 1995c; Izraylevich et al. 1995). *Hemisarcoptes coccophagus* has been introducted from Israel to New Zealand to control various species of armored scale insects (Diaspididae) (Hill et al. 1993; Charles et al. 1995, 1998).

Hemisarcoptes coccophagus was known as a predator of the San Jose scale, *Diaspidiotus perniciosus* (Comstock), *Aonidiella aurantii* (Mask.), and *A. citrina* (Cog.) (Diaspididae) in Turkey (Düzgüneş et al. 1975). *Chionaspis salicis* is a new host record for *H. coccophagus* in Turkey. The objectives of this study are to contribute to the knowledge of the biology and mite-host relationships of *H. coccophagus* under Erzurum ecological conditions.

Materials and Methods

The study was conducted in willow stands containing dominant and co-dominant trees from 3 to 7 m high on the campus of Atatürk University (39°54′005″N and 41°14′184″E with an altitude of 1850–1900 m) in Erzurum during 2001–2003. The study area is insecticide free. Erzurum has cold and snowy winters, rainy springs, and dry summers, with an average temperature of 5.3°C in 1950–2003 and relative humidity of 64.2% during the same intervals (Fig. 1).

The samples of *C. salicis* infested willow twigs were collected from April to October at 10–15 day intervals. The number of adults and eggs of *H. coccophagus*, and the number of the eggs and nymphs of the scale insect were recorded from 50 adult female insects randomly selected by lifting each scale cover with a needle. Nymphs of *Hemisarcoptes* are phoretic on coccinellid beetles of the genus *Chilocorus* and occur under the beetle's elytra along the inner surface of the epipleura (Houck and OConnor 1990). Taking into account this situation, irregular searches were made in the field for the presence of *Chilocorus* beetles. For statistical analysis, SPSS 11.0 packet programs were used. Additional surveys were conducted on other willow growing districts of

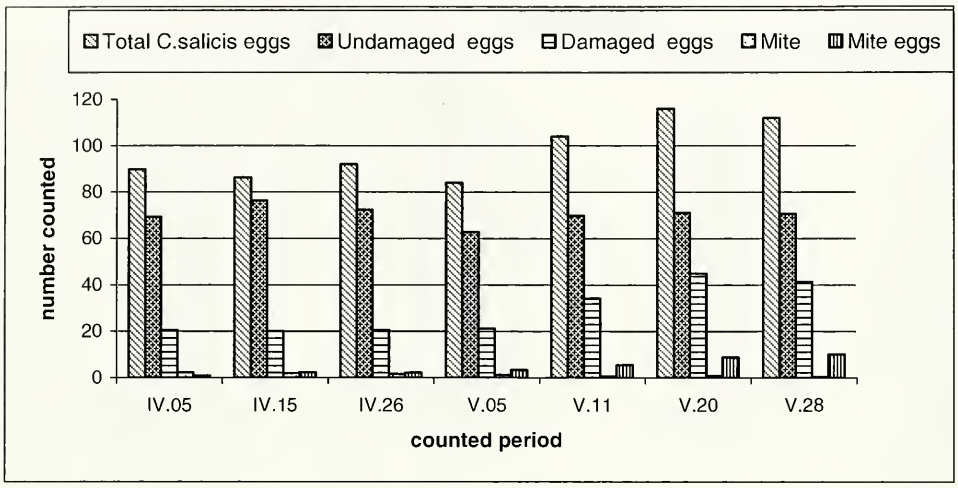
Erzurum to determine if the predatory mite species was present.

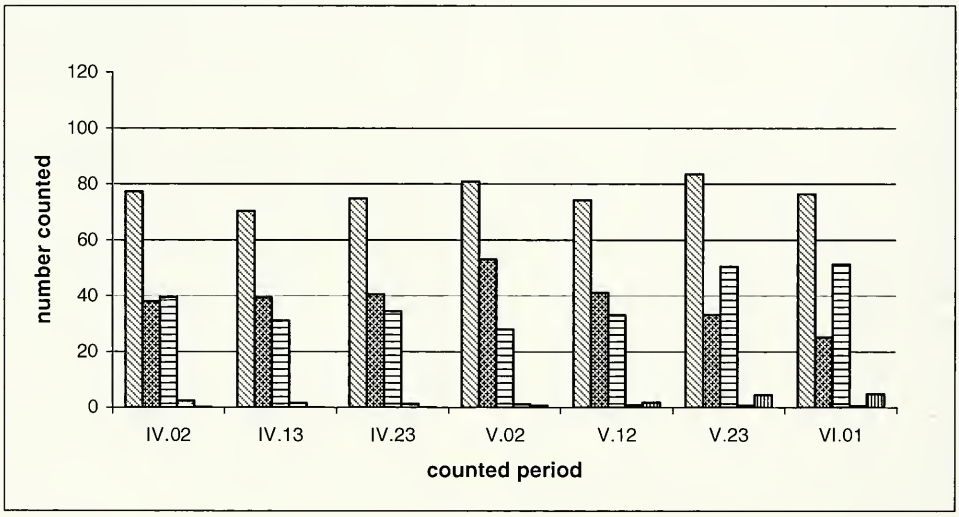
Results and Discussion

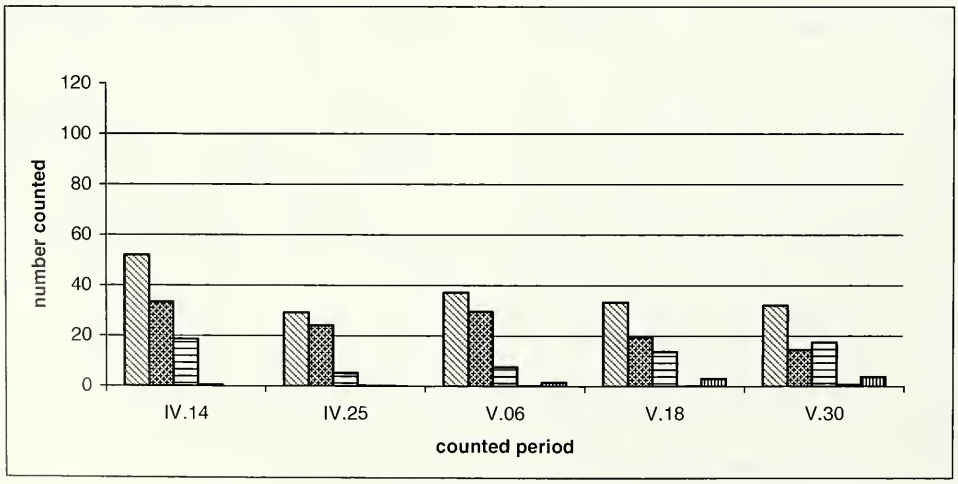
Hemisarcoptes coccophagus was observed feeding on eggs and nymphs of *Chionaspis salicis* in 2000 in Erzurum. Many mites were observed under one scale insect cover. We found from 1 to 31 mites (Mean = 1.05, SE = ±0.15, N = 21) and 0–32 (Mean = 2.57, SE = ±0.62, N = 21) eggs of mites (Fig. 7c). The mites were more abundant on between two twigs and twigs with high populated scale insects (Fig. 7a–b). On infested twigs we counted 24–65 scale insect covers in 1 cm^2-area (Mean = 47.75, SE = ±4.35, N = 12) (Fig. 7d). Under one shield 30–116 eggs of scale insect (Mean = 73.96, SE = ±5.42, N = 21) were counted.

The mite overwinters as adult and nymphal stage under the cover of *C. salicis*. Occasionally eggs were encountered during the examination of the shields during the winter. Overwintering *H. coccophagus* started feeding on eggs of scale insects on April 1, April 13, and April 14 in 2001, 2002, and 2003, respectively (Figs. 2–4). Once the predatory mite consumed all the eggs under a shield, it moved to an adjacent scale insect and entered through a proper opening between the shield and bark of the plant and repeated the process. The female mite laid eggs among the eggs of the scale insect between April 1–5, April 25–30, and April 14–20 in 2001, 2002, and 2003 respectively (Fig. 7). The eggs of the scale insect hatched May 18–28, May 16–23, and May 21–30 in 2001, 2002, and 2003 respectively. The mite average consumption capacity was established as 35% and it was 26%, 49%, and 34% in 2001, 2002, and 2003 respectively. The mite also fed on the scale insect nymphs both under the cover before the nymphs left and also while crawling on the bark. For feeding, the mite inserted its mouth parts into the body of the nymph ventrally and sucked the body fluids. The female mites laid second generation eggs under the cover of the nymphs of scale insect between June 13–17, July 7–12 and July 1–7 in 2001, 2002, and 2003, respectively and the developmental cycle was repeated. The eggs hatched in June 27–30, July 23–26, and July 15–17 in 2001, 2002, and 2003, respectively. The females of the new generation of the scale insects laid their eggs between July 27–30, August 26–30, and August 20–25 in 2001, 2002, and 2003, respectively. The mite continued feeding on the scale eggs and the average damage for the three years was about 25%. The mite laid its third generation of eggs during August 26–September 2. These eggs hatched on September 9–12, September 20–24, and October 9–11 in 2001, 2002, and 2003, respectively. Feeding continued until about the end of October. The fall counting was conducted in 2002 and 2003 (Figs. 5–6). Damaged scale eggs were in lower numbers than in the spring (mean: 14.43 SE = ±4.78, N: 6), 24% of the eggs of *C. salicis* was consumed. Consequently, under the ecological conditions of Erzurum, *H. Coccophagus* has three generations each year.

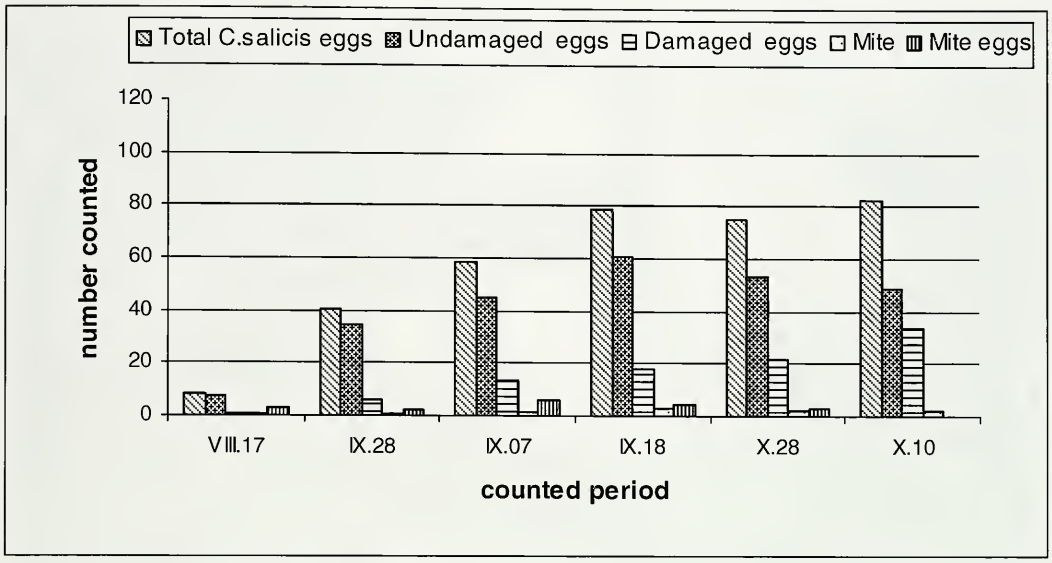
We found the ladybird beetle, *Chilocorus bipustulatus* (L.) (Coleoptera: Coccinellidae) associated with *C. salicis* and *H. coccophagus* at the study site. We observed mites attached under the elytra of the beetle around the anterolateral margins. It has been known that the heteromorphic deutonymphal stage (hypopus) of *Hemisercoptes* is adapted for phoresy and is dispersed by *Chilocorus* adults (Houck and OConnor 1991, Charles et al. 1995). However, the population of *C. bipustulatus* was very low; during the entire year we encountered only 15 beetles and each beetle had 18 mites, whereas, Houck and OConnor (1990) observed as many as 800 mites per

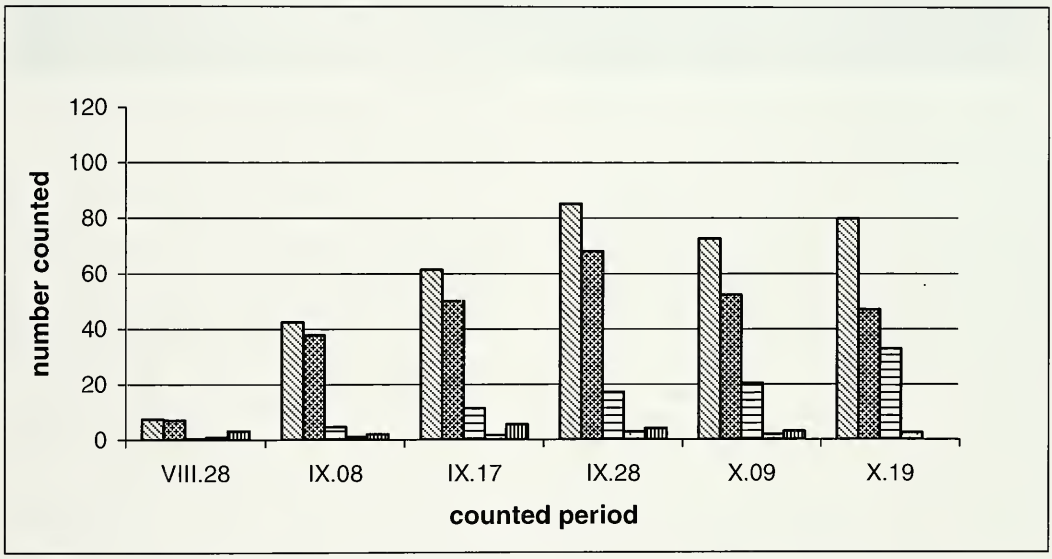






Figs. 2–4. Feeding of *Hemisarcoptes coccophagus* on *Chionaspis salicis* in the spring of 2001 (top), spring of 2002 (middle), and spring of 2003 (bottom).





Figs. 5–6. Feeding of *Hemisarcoptes coccophagus* on *Chionaspis salicis* in fall of 2002 (top), and fall of 2003 (bottom).

beetle under natural field conditions. Based on our observations, we concluded that the mites may be able to live and scatter in the absence of *Chilocorus* beetles. Charles et al. (1995) and Ji et al. (1994) reached a similar conclusion that *Hemisercoptes* species could survive and disperse slowly in the absence of ladybird beetles.

Prey and predator relationships in natural conditions revealed that *H. coccophagus* is a voracious feeder, capable of consuming large numbers of eggs of *C. salicis*. It influenced the population

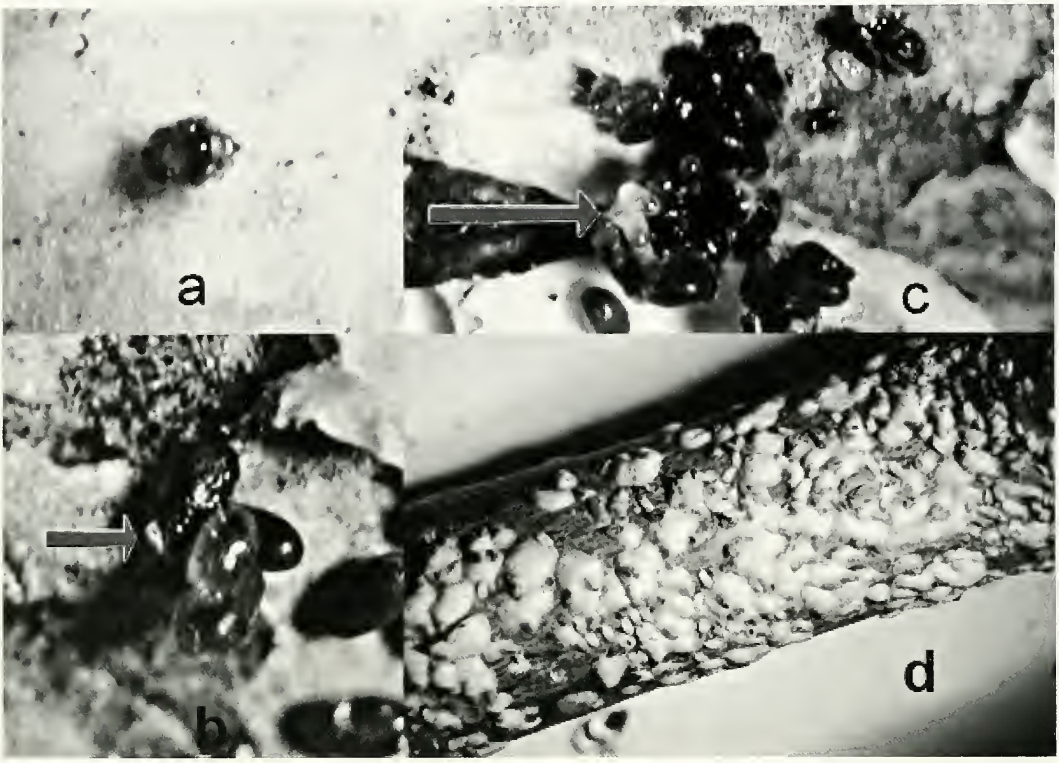


Fig. 7. a,b, Adult of *Hemisarcoptes coccophagus*. c, Eggs of *H. coccophagus* and *Chionaspis salicis*. d, Shell and nymph of *C. salicis* on willow branch.

density of this scale insect (egg destruction is up to 49%), despite the low population of *C. bipustulatus* and the harsh climatic conditions in Erzurum. Since *H. coccophagus* has been successful in the control of various diaspid species, such as *Diaspidiotus perniciosus* (Comstock), *D.* ostrea*eformis* (Curtis), *Lepidosaphes ulmi* (L.), *Hemiberlesisia lataniae (Signoret)* (Charles et al. 1995, 1998); *H. coccophagus* could be considered a candidate for biological control of *C. salicis* in Turkey. Further research is needed to develop mass production strategies and mechanisms for successful field releases of this predatory mite.

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